

Meiosis and Fertilization

Text reference: Chapter 5, Section 5.3, 5.4.

Problem

What effect does the random assortment of genes during meiosis have on the characteristics of the offspring?

Background

Meiosis is the kind of cell division that, in some organisms, produces special haploid cells called *gametes*. In meiosis, chromosomes are randomly shuffled. As a result, the offspring of organisms that reproduce sexually have a mixture of both parents' genes. This variety contributes to the adaptability, and therefore survival, of a species. In this lab, you will simulate the random assortment of human genes and explore the variety of genotypes and phenotypes that characterize the offspring. Recall that homozygous-dominant offspring for a trait have received the dominant gene for that trait from both parents. Heterozygous-dominant offspring have the same phenotype as the homozygous-dominant offspring but have a heterozygous genotype. They have received one gamete carrying the recessive gene and another gamete carrying the dominant gene. You will determine genotypes and phenotypes for gender, tongue rolling, earlobes, mid-digital hair, hairline, and thumb shape.

Materials (per pair)

scissors glue

Safety First!

In this lab investigation, observe the precaution listed below. If you see a safety icon beside a step in the procedure, refer to the list below for its meaning.



- **CAUTION:** Be careful when using sharp tools. (Step 4.)

Time Required

- 40 minutes for Part A
- 40 minutes for Part B

Objectives

- Construct data records of crosses and determine genotypes and phenotypes.
- Make simple models of human gene pairs.
- Model the actions of human chromosomes during meiosis and fertilization.
- Analyze the patterns of inheritance that occur.


Advance Preparation

Chromosome templates

Make photocopies of page 100 for the entire class.

Procedure

PART A

1. Work with a partner. First, examine the drawings on page 99 showing phenotypes for 6 different traits. Note which traits are dominant and which are recessive. Determine which genotypes each of you will choose for the traits. You may use your own genotype if you know what it is or make up the genotype of one parent. Your partner will choose the genotype of the other parent. Try to make choices that will produce as much variety as possible.
2. Fill in Data Table 1 with the choices you made in step 1. Note that each trait is labeled with a chromosome number corresponding to the numbers on the drawings in step 1. Be sure to "express" the phenotype that would result from each genotype. With your partner, decide on a female name and a male name for the parents.
3. Use the diagram of the 6 pairs of homologous chromosomes provided by your teacher. Transfer the names (or initials) you have chosen to each pair of autosomal chromosomes and to the appropriate sex chromosome type. Then transfer the genotype for each trait on your pedigree chart to the chromosome pair with the corresponding number. Be sure to write only one allele on each side of the chromosome.
-  4. Cut along the dotted line surrounding each pair of chromosomes. **CAUTION:** *Handle scissors carefully.* Fold the pairs in half and glue them together. Flatten each pair by pressing down with the heel of your palm.

PART B

1. You and your partner should stand about 1 m apart. Each should drop his or her paper chromosomes to the floor. Examine the alleles facing up on the floor. The alleles that land face up will be the genes that the child inherits.
2. Pick up the alleles and, keeping them face up, arrange them on the lab countertop. The two piles should then be pushed together, and the alleles for each trait should be paired.
3. Complete Data Table 2 for the "child." If you wish, name the child based on the pair of sex chromosomes resulting from "meiosis" and "fertilization."
4. Repeat steps 1–3 two more times in order to have three "children."

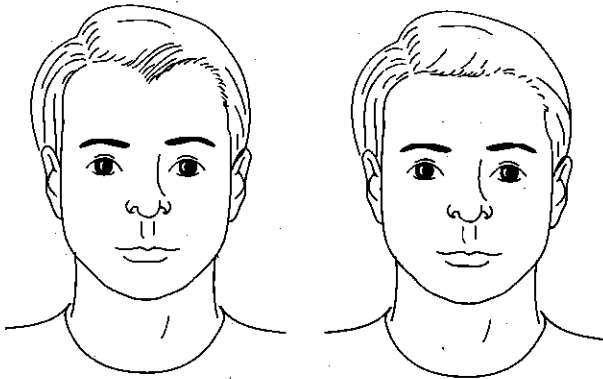
Students may need a demonstration of the lab before proceeding.

If students wish to use their own genotype, recommend that lab partners observe each other to confirm phenotypes.

Other allele traits that assort independently and that students may wish to choose are cleft chin, left-over-right thumb crossing, eyelash length, lip protrusion, and hair texture.

Be sure that students understand that if they have a dominant trait they can only guess about their genotype because they may be either heterozygous or homozygous for the trait.

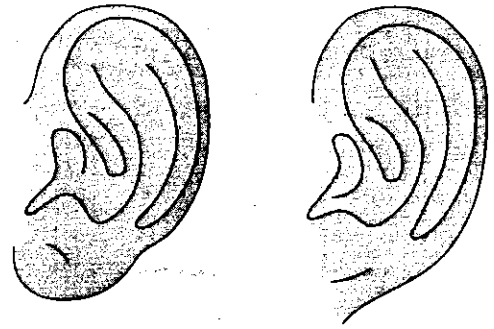
Chromosome 1 HAIRLINE



Widow's peak: WW, Ww
(dominant)

No peak: ww
(recessive)

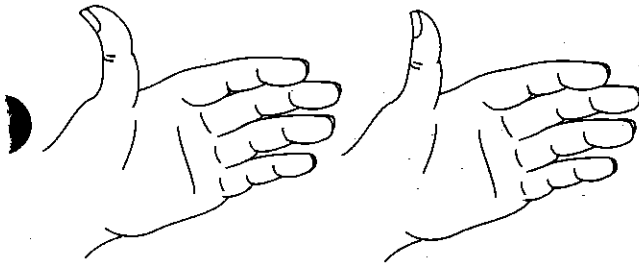
Chromosome 4 EARS



Lobed: LL, Ll
(dominant)

Attached: ll
(recessive)

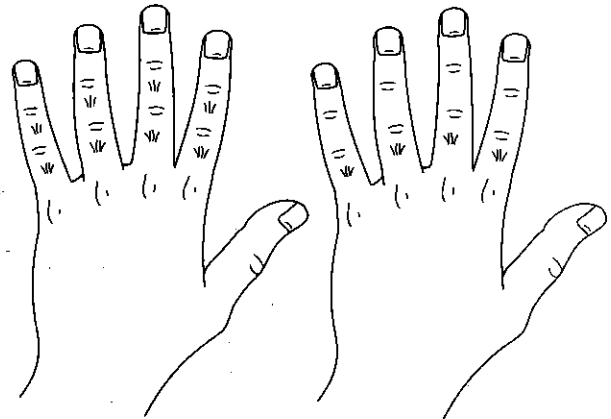
Chromosome 2 THUMB



Curves back: TT, Tt
(dominant)

Straight: tt
(recessive)

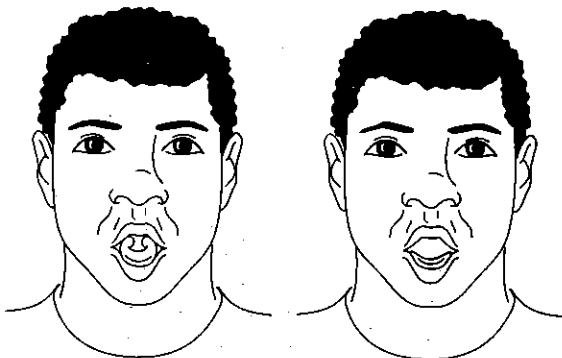
Chromosome 5 HANDS



Mid-digital hair: HH, Hh
(dominant)

Lack of mid-digital hair: hh
(recessive)

Chromosome 3 TONGUE ROLLING



Ability to roll: RR, Rr
(dominant)

Inability to roll: rr
(recessive)

Chromosome 6 SEX



Female: XX

Male: XY

CHROMOSOMES

Chromosome 1

1	1
Phenotype _____ Parent _____	Gene _____ Phenotype _____ Parent _____

Chromosome 2

2	2
Phenotype _____ Parent _____	Gene _____ Phenotype _____ Parent _____

Chromosome 3

3	3
Phenotype _____ Parent _____	Gene _____ Phenotype _____ Parent _____

Chromosome 4

4	4
Phenotype _____ Parent _____	Gene _____ Phenotype _____ Parent _____

Chromosome 5

5	5
Phenotype _____ Parent _____	Gene _____ Phenotype _____ Parent _____

Chromosome 6

6	6
Phenotype _____ Parent _____	Gene _____ Phenotype _____ Parent _____

SAMPLE

4	4
Phenotype _____ Parent _____	Lobe _____ Gene _____ Janette _____

Observations

Data Table 1: Traits of Parents

Parent's Name: _____

Genotypes	Phenotypes
1.	
2.	
3	
4.	
5.	
6.	

Parent's Name: _____

Genotypes	Phenotypes
1.	
2.	
3	
4.	
5.	
6.	

Data Table 2: Traits of Children

Child's Name: _____

Genotypes	Phenotypes
1.	
2.	
3	
4.	
5.	
6.	

Child's Name: _____

Genotypes	Phenotypes
1.	
2.	
3	
4.	
5.	
6.	

Child's Name: _____

Genotypes	Phenotypes
1.	
2.	
3	
4.	
5.	
6.	

Analyses and Conclusion

1. Identify which step simulated the random assortment of genes that occurs during meiosis. Which step simulated fertilization?
2. Identify each trait, if any, where both parents were homozygous recessive. Identify the genotype and phenotype of the offspring.
3. Identify each trait, if any, where both parents were heterozygous. What are the possible genotypes and phenotypes of the offspring when both parents are heterozygous?
4. Does the combination of genes in the first child change what genes will be available to subsequent children? Explain why or why not.
5. Suppose both parents are **Rr** for the tongue-rolling trait. By random assortment and pairing, predict what traits their offspring might have if they have four children.

Going Further

Propose a hypothesis about the inheritance pattern of a pair of genes that you did not test.

Design an experiment to test your hypothesis.